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Biological Control of *Callosobruchus maculatus* (F.) in Stored Pigeonpea *Cajanus cajan* (L.)

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ABSTRACT: Pigeonpea, *Cajanus cajan*, (L.) is a vital legume in the Indian subcontinent, not just in terms of production but also providing nutrient security to a large chunk of population, the pulse however faces issues related to frequent and prominent pest attacks, one such issue is the attack of *C. maculatus* on the pulses in fields and storehouses leading to tremendous losses in the amount of grain produced as well as monetary losses incurred in grain production and storage. There are methodologies available to address the insect attack in pigeonpea by the use of chemicals, aimed at reducing pest damage but at cost of health hazards and other problems. However, use of biocontrol agents for pest management is an approach that is novel but with scarcity in research material. This study aimed to investigate the parasitoids of *C. maculatus* available in storehouses for its biological control. Both larval parasites *viz*., *Dinarmus basalis* and *Triaspis* sp. parasitized the grubs of *C. maculatus* as ecto and endo parasites. In the whole sample, 14.74 per cent mortality of *C. maculatus* was noted by the 22.83 parasites. *Dinarmus basalis* and *Triaspis* sp. parasitized 13.25 and 1.49 per cent mortality of *C. maculatus*, respectively which is in a very little extent of parasitization to control the bruchids in store.

Keywords: Pigeonpea, *Callosobruchus maculatus*, Biological control, Parasitoids, *Dinarmus basalis.*

INTRODUCTION

In the realm of agricultural significance, pigeonpea, *Cajanus cajan* (L.) stands as a fundamental legume crop known for its vital role in enhancing dietary diversity and supporting the socioeconomic well-being of various communities. Recognized for its nutritional richness and extensive cultivation across diverse regions, the importance of pigeon pea remains indisputable. However, the susceptibility of pigeon pea to infestation by the pulse beetle, scientifically referred to as *Callosobruchus maculatus*, presents a significant challenge, demanding an immediate need for comprehensive understanding and effective mitigation strategies. The pulse beetle, a formidable adversary to legume crops, has emerged as a substantial threat, resulting in significant protein content losses within pigeon pea grains. The impact of this menace on developing nations varies from 12% to 30% (Tsedeke, 1985), with its presence being widely observed in field conditions (Mohan and Subbarao 2000). What initiates as an infestation by *C. maculatus* in the field extends into storage conditions (Karthik *et al.*, 2023). While its field occurrence might commence moderately, it serves as a catalyst for exponential population growth post-harvest, leading to notable losses within storage facilities (Khavilkar and Dalvi 1984). Empirical records by Gujar and Yadav (1978) underscore the alarming consequences, revealing a staggering reduction of 55% to 60% in seed weight and a remarkable decline of 45.50% to 66.30% in protein content due to damage inflicted by the pulse beetle. Furthermore, a temporal progression highlights that three to six months subsequent to the initial infestation, up to 90% of the beans become vulnerable to infestation, coupled with weight losses ranging from 30% to 60% (Caswell, 1981). Although chemical interventions or radiation may appear as plausible solutions for *C. maculatus* control, they prove unfeasible for resource-constrained farmers. Remarkably limited efforts have been allocated to the biological management of stored product pests, particularly bruchids, within the context of India. Against this backdrop, the current study pivots towards elucidating the presence of the bruchid parasitoid within storage facilities and delving into various biological aspects of this parasitoid species concerning bruchid infestations within grain storehouses. With an overarching goal to contribute to the realm of sustainable pest management strategies, this study embarks on a comprehensive exploration of the intricate dynamics between bruchids, their parasitic counterparts, and the pigeon pea grains they inhabit. Through an in-depth analysis of biological interactions and ecological nuances, we strive to illuminate innovative approaches that hold the potential to mitigate the pervasive impact of pulse beetle infestations on this crucial legume crop.

MATERIAL AND METHODS

A. Rearing of Callosobruchus maculatus

The pulse beetle, scientifically known as *Callosobruchus maculatus*, was cultured in a controlled laboratory setting using cowpea plants as their food. The lab conditions were maintained at a steady temperature of 27±1°C and a humidity level of 70±1% RH. To start the rearing process, we placed adult beetles from infested grains into plastic containers with disinfected cowpea plants. Once these adult beetles laid their eggs, we took them out of the containers. The newly hatched beetles were then released onto fresh cowpea or moongbean plants for mating and laying more eggs. This whole cycle was repeated every 15 days to ensure we always had different stages of the insects available for our research.

B. To study extent of parasitism

Forced feeding of *C.maculatus* on pigeon pea seeds. Observations were made by inducing *C. maculatus* for oviposition on fresh seeds. In 11 Petri dishes egg free fresh seeds were taken and placed inside the big glass jar, where stock culture of *C. maculatus* was present in heavy amount. Glass jar was surrounded by black paper and mouth of jar was covered with muslin cloth. Petri dish having fresh seeds were kept inside for only two days to avoid hatching. After two days Petri dishes were removed out and selected 100 seeds (containing 2-3 eggs) were shifted in the different part of the store house to maintain homogeneity in the experiment. These Petri dishes were placed openly (except one Petri dish which was used as control, was covered) for ten days in the month of July when these parasites were found maximum in numbers. After ten days Petri dishes were covered and transferred in to laboratory for regular observation. Following observations were recorded:

1. Total number of seeds in each Petri dish.
2. Total number of eggs in each Petri dish.
3. Total number of parasitized eggs in each Petri dishes.
4. Total number of parasitoids emerged in each Petri dish.
5. Total number of bruchids adult emerged in each Petri dishes.

The experiment was carried out two years consecutively to have a clear understanding regarding parasites/ parasitoids reported in godowns feeding on *C. maculatus* for its biological control.

To study frequency of parasitoids in storehouse: Month wise collection of pigeonpea seeds and emergence of these parasites identified were counted from ten samples collected from different parts of the store house. The month wise records shows the frequency of the parasitoid in different parts of the year. Eggs laid by *C. maculatus* on pigeonpea seeds with forced feeding were kept in the store house for parasitization up to ten days. Under confinement 100 seeds having 2-3 eggs/seed were kept in petridishes for parasitization of bruchids.

RESULTS AND DISCUSSION

Throughout, experimental study, the presence of egg parasites was notably absent, as no black-colored parasitized eggs were detected in any of the samples. In-depth analysis of the parasitized samples revealed the presence of two hymenopteran parasitoids identified as *Dinarmus basalis* and *Triaspis* sp on a morphology based identification with the help of microscope. These findings align with the findings of George (1990), who reported that *Dinarmus basalis*, a natural enemy of bruchids during their larval stage, serves as a solitary, *idiobiont ectoparasitoid* of immature and recently-formed adults of various bruchid species found on legumes, however *Triaspis* sp was recorded as larval endoparasitoid. (Verma, 1991). The observed behavior of parasitoids highlights its synovigenic nature, wherein females consistently produce eggs throughout their entire adult stage (Nishimura, 1993). This behaviour enables them to actively navigate within stored grain columns in search of seeds harboring bruchid larvae a trait previously noted by Gauthier *et al*. (1999). Our investigation revealed that population of *Dinarmus* was more and *Triaspis* was observed very less in number, Activity of these parasites was observed as maximum during rainy season from July to October. Whereas, minimum or nil during summer season. Humidity plays the most important role for increase or decline of the population of these parasites, an average of 19.5 *Dinarmus basalis* and 2.2 *Triaspis* sp adults emerged from each sample (Table 1), which is in alignment with the work of George (1990) but slightly exceeds the emergence rate of approximately 9% reported by the same author. This discrepancy might be attributed to regional variations and differing environmental conditions at the collection sites of our samples. Interestingly, our study discovered that additional bruchid eggs were laid during the ten-day parasitization period. Each sample exhibited an average of 238.3 eggs (Table 1). This phenomenon could have implications for understanding the reproductive dynamics of bruchids and their interaction with respective parasitoids. The emergence of *Callosobruchus maculatus* adults was notably robust, with an average of 81.00 adults emerging per sample. In contrast, the control treatment, despite meticulous precautions to prevent parasitization, only yielded 95 adults. This discrepancy underscores the effectiveness of the treatments and further emphasizes the role of *Dinarmus* and *Triaspis* sp. as a significant natural enemy in controlling the emergence of *Callosobruchus maculatus*.

In the whole sample 14.74 per cent mortality of *C. maculatus*, was noted by 22.83 *parasites. Dinarmus basalis* and *Triaspis* sp. parasitized 13.25 and 1 .49 per cent mortality of *C. maculatus*, which is in a very little extent of parasitization to control the bruchids in store, the ratio of population of natural enemy to pest was also very low. Similar findings were reported by Sanon *et* *al.* (1998) who stated a high ratio of parasitoids to host larvae and pupae was critical for the successful biological control. It is only when this ratio is high that *C. maculatus* populations can be controlled. In our studies the ratio was not much between parasitoid and pest populations leading to lower pest management. Observations were based on emergence of parasites from collected samples in each of the month of both the years. Throughout the study period the maximum temperature recorded did not exceed 43.8°C and minimum temperature was capped at 4.7°C. The highest humidity recorded was 95.7%.

Table 1: Extent of parasitism from various locations in the storehouse.

Sample No.	No. of grains having eggs in each sample	Total no. of eggs in sample (before putting in storehouse)	No. of parasitised (black) eggs	No. of *Dinarmus basalis* emerged	No. of *Triaspis* sp. emerged	No. of bruchus eggs in each sample (after parasitization)	No. of *C. maculatus* emerged in each sample
1	100	200	0	20	0	210	80
2	100	210	0	21	0	210	83
3	100	215	0	25	5	215	78
4	100	225	0	0	1	230	92
5	100	200	0	35	4	218	62
6	100	235	0	30	0	250	75
7	100	250	0	32	3	250	76
8	100	250	0	27	0	255	85
9	100	260	0	0	4	265	90
10	100	265	0	5	5	280	89
Control	**100**	**250**	0	**x**	**x**	**x**	**95**
Mean		**232.73**		**19.5**	**2.2**	**238.3**	**81**

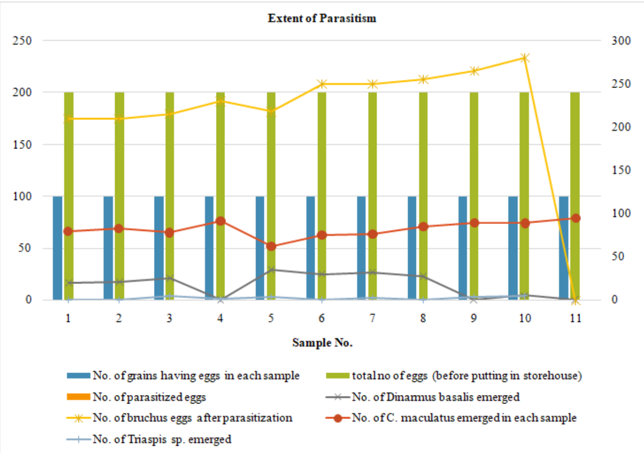

Fig. 1. The extent of parasitism of *Dinarmus basalis and Triaspis* sp. on *C. maculatus* emergence.

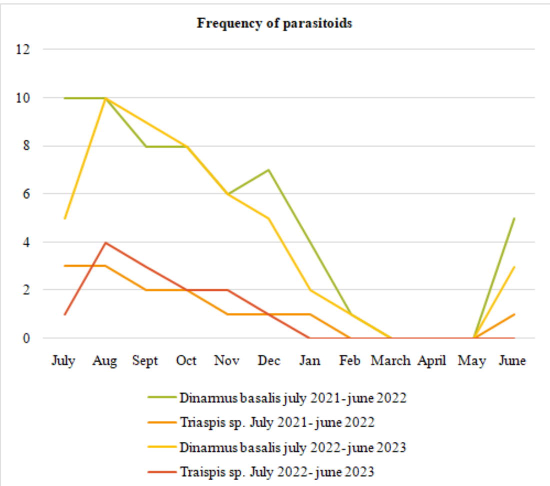

Fig. 2. Monthly frequency of the parasitoid in the storehouse.

Table 2: Frequency of parasitoids occurrence each month for period of 2 years.

No. of samples examined from which parasitoid emerged	Months											
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
July 2021-June 2022												
Dinarmus basalis sp.	10	10	8	8	6	7	4	1	0	0	0	5
Traispis sp.	3	3	2	2	1	1	1	0	0	0	0	1
July 2022-June 2023 *Dinarmus basalis*	5	10	9	8	6	5	2	1	0	0	0	3
Triaspis sp.	1	4	3	2	2	1	0	0	0	0	0	0

Fig. 3. *Triaspis* sp. recorded during experiment.

Fig. 4. *Dinarmus basalis* emerged from tested samples.

The results clearly indicate that all samples of bruchids were mostly parasitized by *Dinarmus basalis* (Fig. 4) and *triaspis* sp (Fig. 3.), during first year of July, August and second year of August September months. Minimum emergence of parasitoid was observed during month of January, February and June of both the years. Maximum emergence of parasites were observed with high humidity in both the years. Maximum build-up of parasitoids was observed during July to October months both the years because of high humidity. The findings are in confirmation with George (1990), who stated that greater frequency of *Dinarmus basalis* was observed from July to November indicating that high humidity is necessary for the development of parasitoid.

CONCLUSIONS

In summary of the current laboratory experiment, the findings underscore the remarkable capacity of the parasitoid *Dinarmus basalis* and *Triaspis* sp. to exert a substantial suppressive impact on the bruchid population. It is noteworthy that the prevalence of the parasitoid within storehouses remained notably limited. This observation accentuates the potential for significantly enhanced pest management outcomes through the augmentation of the parasitoid population within storage facilities. The implications of this study reveal a pivotal avenue for future research and application.

By fostering an increase in the parasitoid population, the prospects for a markedly improved and highly efficient strategy for bruchid pest management within storage contexts become evident. Consequently, there arises a critical imperative to establish standardized mass production techniques tailored to the expansion of the parasitoids population on a substantial scale. Such standardization holds the promise of enabling widespread release in storage facilities, thereby ushering in a paradigm shift in the effective control of the pulse beetle menace. In closing, this research underscores the substantial potential for advancing integrated pest management through the strategic augmentation of the parasitoid *Dinarmus basalis* population.

FUTURE SCOPE

The journey ahead calls for the harmonization of rigorous scientific inquiry with pragmatic field applications, culminating in the development of a comprehensive and sustainable approach to safeguarding stored pulses. The establishment of mass production protocols stands as a pivotal milestone on this transformative path, fostering optimism for a future where the resilience of stored commodities against bruchid infestations is assured through innovative and ecologically sensitive means.

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